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FERTILIZATION INCREASES DIAMETER GROWTH OF BIRCH-BEECH-MAPLE TREES IN NEW HAMPSHIRE

Abstract. — In a 60-year-old northern hardwood stand treated with lime plus NPK fertilizer, the following increases in average basal area growth rate over untreated trees were observed: sugar maple 128 percent, paper birch 69 percent, yellow birch 51 percent, and beech 20 percent. Magnitude of response was inversely related to relative growth rate of the species. Growth rate before treatment was used as a covariate to adjust treatment means for differences in vigor of the trees.

Fertility of forest soils in New England is generally low. Nutritional limitations on growth are common on many sites in this region. Mitchell and Chandler (*2*) showed that there is a strong relationship between nitrogen supply and radial increment of several deciduous trees of the Northeast and estimated that only 15 percent of the soils supporting hardwood species had an optimum nitrogen status. Hoyle and Bjorkbom (*1*) emphasized that not only N but also, P, Ca, and Mg in mineral soils in New Hampshire were deficient for growth of yellow birch. Yet there have been few field trials of fertilizers in northern hardwood forests to test the effects of fertilizers on tree growth response.

This note is a report on increased diameter growth of four northern hardwood species after combined application of dolomitic limestone and NPK fertilizer.

Study Area

This trial was established as a timber-stand-improvement project in the Bartlett Experimental Forest in the White Mountain National Forest in New Hampshire. The site is at about 300 m (1,000 ft) elevation on gentle 5-10 percent slope with northerly aspect. The soil is a coarse loam, classified as a Typic Fragiorthod in the Becket series.

This stand contained 30 m² per ha (130 ft² per A) of basal area, with the following species distribution: American beech (*Fagus grandifolia* Ehrl.) 36 percent; red maple (*Acer rubrum* L.) 21 percent; sugar maple (*A. sac-*

charum Marsh.) 13 percent; yellow birch (*Betula alleghaniensis* Britton) 12 percent; paper birch (*B. papyrifera* Marsh.) 12 percent; and other species 5 percent. Average height of dominant and co-dominant trees was 20 m (65 ft); age was 90 years.

A block of 10 contiguous .4-ha (1-acre) plots was established, and 1,120 kg/ha (1,000 lb/A) of dolomitic limestone (30% CaO, 20% MgO) were broadcast by hand over the entire area in the fall of 1963. One of the .4-ha plots received 3,360 kg/ha (3,000 lb/A) of 15-10-10 NPK fertilizer in a broadcast application in April 1964 and a second application of NPK (same amount) in June 1969. This was equivalent to 240 kg/ha (214 lb/A) Ca and 120 kg/ha (107 lb/A) of Mg for the entire block, plus 1,008 kg/ha (900 lb/A) N, 369 kg/ha (330 lb/A) P, and 558 kg/ha (500 lb/A) K on the lime + NPK plot.

Growth Measurements and Analysis

After the 1971 growing season, increment cores were taken from 10 trees each of yellow birch, paper birch, sugar maple, and beech on the limed area, the lime + NPK plot, and the surrounding untreated stand. Only healthy dominant or co-dominant trees 5 m or more from plot boundaries were chosen. Mean and range of 1971 dbh for measured trees were as follows: sugar maple 25 cm (15-50), yellow birch 26 cm (15-37), paper birch 30 cm (21-43), and beech 25 cm (18-35). The ranges in tree sizes were about the same for the three treatments.

Radial growth for the period after treatment (1964-71) and for the corresponding 8-year period before treatment (1956-63) was measured on each of the 120 increment cores. Measuremnets were to the nearest 0.25 mm. Initial diameters were calculated by subtracting 2 times radial increment from present dbh outside bark. Thus bark thickness was assumed to be a constant and unaffected by treatment. Relative basal-area growth — cm^2 per 100 cm^2 initial basal area per tree — was calculated.

Analysis of covariance (3) was performed on relative basal-area increase since treatment (1964-71), using relative basal-area increase before treatment (1956-63) as the covariate. A preliminary analysis suggested that for each species the regression coefficients were the same for the three treatments. Therefore the growth model used in the study assumes a common regression coefficient for the covariate.

Results

For each species, mean relative basal-area growth of trees from the lime + NPK plot was greater than that of untreated trees. In addition all species from the lime-only treatment — especially paper birch and sugar maple trees — had greater basal-area increment than trees from the control area (table 1). Untreated sugar maple trees were the slowest growing and made the greatest response to treatment. Untreated beech trees were the fastest growing and showed the least response to treatment.

The pattern of differences among growth rates of untreated and treated trees before treatment (table 2) was similar to that after treatment. The only difference in this pattern

Table 1. — *Average relative basal-area growth per tree after fertilizer treatment (1964-71)*

[cm^2 per 100 cm^2 per tree]

Species	Treatment		
	Control	Lime	Lime + NPK
Yellow birch	3.7	4.2	9.5
Paper birch	3.3	3.9	4.9
Sugar maple	2.8	4.9	8.8
Beech	7.1	7.4	9.4

Table 2. — *Average relative basal-area growth per tree before fertilizer treatment (1956-63)*

[cm^2 per 100 cm^2 per tree]

Species	Treatment		
	Control	Lime	Lime + NPK
Yellow birch	4.2	4.4	7.8
Paper birch	4.6	5.3	3.8
Sugar maple	4.2	8.1	7.3
Beech	8.8	9.0	10.2

was with paper birch: where lime only was used, trees had the highest basal-area increment; and where lime + NPK were used, the lowest. These pretreatment growth patterns cloud the response to treatment referred to in table 1. Were the differences reported in table 1 caused by the treatments, or by an influence of the pretreatment growth rate shown in table 2?

To answer this question, mean basal-area growth after treatment was adjusted for basal-area growth before treatment by a covariance technique (table 3). The pattern of mean values was similar to the uncorrected growth rates in table 1. Effect of treatment was significant at the 1-percent level for paper birch and sugar maple, and at the 10-percent level for yellow birch. Treatment effects on beech were not significant.

Table 3. — *Average relative basal-area growth per tree after fertilizer treatment (1964-71) corrected by covariance for growth rate before treatment (1956-63)*

[cm^2 per 100 cm^2 per tree]

Species	Treatment		
	Control	Lime	Lime + NPK
Yellow birch[a]	4.9	5.2 (6)[b]	7.4 (51)
Paper birch[c]	3.2	3.5 (9)	5.4 (69)
Sugar maple[c]	3.7	4.4 (19)	8.5 (128)
Beech[d]	7.4	7.5 (1)	8.9 (20)

[a]Treatment effects significant at 10% level by analysis of covariance.
[b]Figures in parentheses show percent increase over control.
[c]Treatment effects significant at 1% level by analysis of covariance.
[d]Treatment effects not significant.

In the lime-only treatment, the greater growth of paper birch and sugar maple shown in table 1 was evidently attributable to growth rate before treatment, because the adjusted treatment means (table 3) are only slightly greater than that of untreated trees.

Sugar maple growth was more than doubled by the lime + NPK treatment. Paper and yellow birch growth was increased by more than 50 percent. Beech showed a 20-percent increase—though not statistically significant.

Discussion

The results of this small study indicated that species of advanced age growing together in mixed stands may respond differentially to fertilizer treatment. Paper birch, an intolerant pioneer species, approaching overmaturity at 90 years, showed a substantial response to fertilizer. Beech, a tolerant climax species and the fastest growing species in the untreated stand, was only slightly stimulated. These results suggest that research into the possible use of nutrient manipulation as a means of influencing species dominance in mixed northern hardwood stands is needed.

Trees in this study apparently were already in a period of declining growth from natural causes. (Compare control and lime-only values in table 1 and table 2 for each species.) Effect of lime + NPK treatment was to reverse this trend and increase increment of treated trees. This raises a question about magnitude of response. Had the trees been growing normally — at a rate equal to the before-treatment rate — would the response to treatment have been greater or less than that observed? Intuitively one would answer greater. More vigorous trees should show a greater response. However, the data for beech, the fastest-growing but least responding species, tend to support the opposite hypothesis.

The important consideration here is that rate of growth before treatment, and trend of control-tree growth after treatment, have an important bearing on the evaluation and interpretation of treatment response. Design of future research studies should incorporate the vigor of the trees being treated as a variable. Growth measurements must cover a sufficient period of time for assessing the interaction of treatment response with uncontrolled sources of growth variation.

Literature Cited

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